Eagle Nest Monitoring Project
Year 2, 2008–09

Nest site use and timing of breeding events

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Disclaimers

The information presented is considered relevant (by the author) to the project.

Analysis and discussion of information has been undertaken to different levels of detail.

Coverage of material may not be complete.

The opinions and interpretations of information in this document are made by the author.

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Cover photograph of Tasmanian wedge-tailed eagle nestling by Leigh Walters.

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Summary

- This report covers the second year of a long-term monitoring project that aims to evaluate the effectiveness of current management prescriptions in reducing adverse effects of activities covered by the forest practices system on the breeding success of the wedge-tailed eagle. The results of this long term project will assist in the ongoing development of management actions.

- The information in this report contributes to the activities outlined in the project description and funding agreement (Appendix A). This project also contributes to recover action 6.1 detailed in the Recovery Plan for Threatened Eagles (Threatened Species Section 2006).

- The first year of this project (07/08 work, see Wiersma *et al*, 2009) established methods and 84 nests for monitoring and made a preliminary exploration of the relationship between nest site and tree characteristics, and the success of a nest site. The study also evaluated the use of indirect signs in determining nest site 'activity status' (Wiersma and Koch, *in review*)

- The specific aim of this second year of the study (08/09) was to use methods developed in 07/08 to determine the use of the 84 nests in 08/09 and the timing of breeding events in 08/09. Work was also carried out in 08/09 on the collection of habitat data to use in an analysis to be conducted after the 09/10 survey season and the review and update of the model used to predict the occurrence of wedge-tailed eagle nesting habitat.

- This report for the 08/09 season should be regarded as an 'interim report'. The three -year report (2007-2010) will address the overall aims of the project in more detail.

- Due to the physical loss of one nest of the 84 chosen for monitoring, only 83 nests were surveyed in 08/09. In addition, twenty-two of the 84 nests established during the 07/08 work (Wiersma *et al*., 2009) either could not be located in the 08/09 survey or the presence/absence of young could not be confirmed. Hence data was collected for only 61 of the original 84 nests.

- Only nine of the 61 nests (15%) surveyed were found to be successful (defined as the presence of a 4-6 week old, or older nestlings). Thirty-eight were not used and 14 were 'maintained'. These results combined with the 07/08 results suggest that a large proportion of nests are not used in any given year.

- Eighteen of the 61 nests had been successful in 07/08. Five of these were successful in both 07/08 and 08/09. Six were not successful in 08/09, although they were recorded as 'maintained'. Seven showed no signs of use during the 08/09 season. 11 of the 61 nests were recorded as 'maintained in 07/08. Two of these were successful in 08/09, five were maintained in 08/09 and four showed no signs of use in 08/09.

- Two of the 61 nests were successful in 08/09 but had not been successful or maintained in 07/08. Nests were more likely to be successful in 08/09 if they had also been successful in 07/08 rather than just 'maintained'.

- A comparison of the timing of breeding events indicated that the 08/09 season started approximately 6 weeks later than the 07/08 season. Such a late season was considered unusual although the actual duration (approximately 44 weeks) was similar to that reported in previous years.

- A number of nests could have been incorrectly assessed as inactive during the routine ‘activity checks’ carried out by forest planners in 08/09, due to the shift in the timing of breeding events. The timing of ‘activity checks’ coincided with the incubation period, when it is difficult to confirm the ‘activity status’ of a nest.

Management recommendations from the 08/09 work -

- The July-Feb breeding season is noted in the literature (Mooney, 2000, Mooney and Holdsworth, 1991). However, management actions to minimise disturbance to eagle nests are currently only required between August – January. This is because it is assumed that the birds are less sensitive to disturbance during the early and later stages of the breeding season. However, the data collected over the past two years has revealed significant variation in the timing of breeding. In 07/08 breeding events occurred between June and April, in 08/09 between July and April. So we suggest that consideration should be given to extending the period when management actions are required (noted in the TFA) to July – Feb inclusive. This would allow for this annual variation in breeding events and ensure disturbance to the main/critical breeding stages are minimised.

- Due to the potential inter-annual variation in the timing of breeding events it may be best to manage all nest sites as active until November. The likelihood of mistakenly identifying a nest site as being ‘inactive’ during September is high in years when the season starts late (as in 08/09).

Introduction

Maintaining viable wedge-tailed eagle breeding populations in Tasmania in the face of disturbances resulting from land use activities is an ongoing challenge for land managers. An understanding of general biology, ecology, habitat requirements and demography is required in order to develop effective management actions for the species. Ongoing monitoring and evaluation of the implementation and effectiveness of the actions is vital to ensure management actions are meeting their objective.

Our knowledge of wedge-tailed eagle breeding biology and the effects of land-use disturbance on wedge-tailed eagles are limited when compared to what is known about related species in this genus. For example, the golden eagle *Aquila chrysaetos* a species closely related to the wedge-tailed eagle, with many similar management problems, is by comparison well studied (Whitfield *et al.* 2007; Whitfield *et al.* 2001). Past research into the effects of land-use disturbance on wedge-tailed eagles has focussed largely on disturbance events in the vicinity of nest sites (Mooney 1988; 1997). The current study aims to considered the impact of disturbance events occurring in the broader landscape (Wiersma *et al.* 2009). While critical, the disturbance at individual nest sites is only one of the factors which are likely to influence breeding success. Factors that influence home range, territory density, demography and habitat relations are also important for breeding success. Gathering data on nests, and relevant environmental parameters in the broader landscape, over successive years will help us to understand natural and unnatural trends in nest success, and the relationship between land-use factors and nest success.

It has been noted that eagle nests and territories are not used for breeding every year (Mooney and Holdsworth 1991). Anecdotal evidence strongly suggests, however, that wedge-tailed eagles are capable of breeding each year when conditions are favourable (DPIW 2008). However, this evidence comes from repeated surveys of only a small number of nests (DPIW 2008) and unless individuals are banded it is difficult to ascertain whether the same pair breeds annually. Nests are known to be the focal point of eagle territories, irrespective of whether nests are used each year for breeding (Mooney 2000; Mooney and Holdsworth 1991; Newton 1979; Olsen 2005; Wiersma *et al.* 2009).

Annual reproductive trends are an important consideration for managing eagle habitat in the long-term. Currently no management actions, apart from the 10 ha reserve, are required at nest sites which are not found to be 'active' (used for breeding). If wedge-tailed eagles are found to be predominantly biennial or triennial breeders, the lack of management actions to ameliorate disturbance in the vicinity of 'inactive' nest sites may affect the use of such nest sites for breeding in subsequent years.

The first year of this current study (Wiersma *et al.* 2009) established methods and 84 monitoring sites to allow preliminary exploration of the relationship between nest site and tree characteristics, and the success of a nest site. The study also evaluated the use of indirect signs in determining nest site 'activity status' (Wiersma and Koch, *in review*). This analysis of nest site characteristics enabled revision of the Nest Activity Sheet used by forest planners (Wiersma *et al.* 2009). This data sheet enables a more accurate assessment of nest use by trained eagle officers. In the past, sites could at best be considered *active*, a term used by the industry to describe a site likely to be frequented or used by a breeding pair. While *active* sites are suitably managed, by implementing a 500m and 1km line of site exclusion zone during the breeding period, actual breeding 'success' is often difficult to determine. The data collected using the revised Nest Activity Sheet enables a more accurate prediction of likely breeding success at a particular nest site.

The focus of this second year (08/09) of the study reported here was to use methods developed in 07/08 to determine the use of the 84 nest sites surveyed in 08/09 season and to determine the timing of breeding events in 08/09. Work was also carried out to collect habitat data to analyse after the 09/10 survey season, selection of more nests to include in the 09/10 survey, and the review and update of the model used to predict the occurrence of wedge-tailed eagle nesting habitat. This report for the 08/09 season should be regarded as an 'interim report'. The three year report (2007-2010) will address the overall aims of the broader project in more detail.

Aims of study

The specific aims of this second year of the study (08/09) were -

- to determine use of nests in 08/09, using methods developed in 07/08,
- identify the timing of breeding events in 08/09, and
- to compare the timing of breeding and usage of nests in 08/09 with 07/08 results reported in Wiersma *et al.* (2009).

Work was also carried out in 08/09 on the selection of a further 92 nests for monitoring in the 09/10 breeding season (July to July) to increase the range of nests in various patch sizes, to enable the influence of forest patch size on breeding success to be evaluated. Habitat data was also collected for the analysis to be conducted after the 09/10 survey season, and work started on reviewing and updating the model used to predict the occurrence of wedge-tailed eagle nesting habitat. The outcomes of this part of the work will be reported on in the three year report (2007-2010).

Methods

Nest sites

An attempt was made to resurvey all the nest sites established in 07/08 (Wiersma et al, 2009) during the 08/09 season (Appendix C). Of the original eighty-four nests surveyed in 07/08, one nest site had fallen down. Nests selected in 07/08 were categorized as 'managed' (nest subject to forest management within 1km) and 'semi-natural' (sites containing no forest management within 1km) nests. The nest categories were re-evaluated prior to 08-09 season to ensure they had not changed. Categories remained the same in 08/09. Twenty-two of the 83 nest sites could not be found during the aerial surveys (Appendix C). A number of these nests were later found during follow-up ground surveys but the breeding status could not be determined because of poor visibility from the ground. The difficulty in observing some nests during the 08/09 season was mainly due to the brown leaf pigment that eucalypts produce to protect leaves in response to drought conditions (Close and Beadle 2003). This brown pigment camouflaged the nests and hence made them difficult to observe during the aerial surveys. As a result data was collected for only 61 of the nest sites (35 managed, 26 semi-natural) in 08/09 (Figure 1).

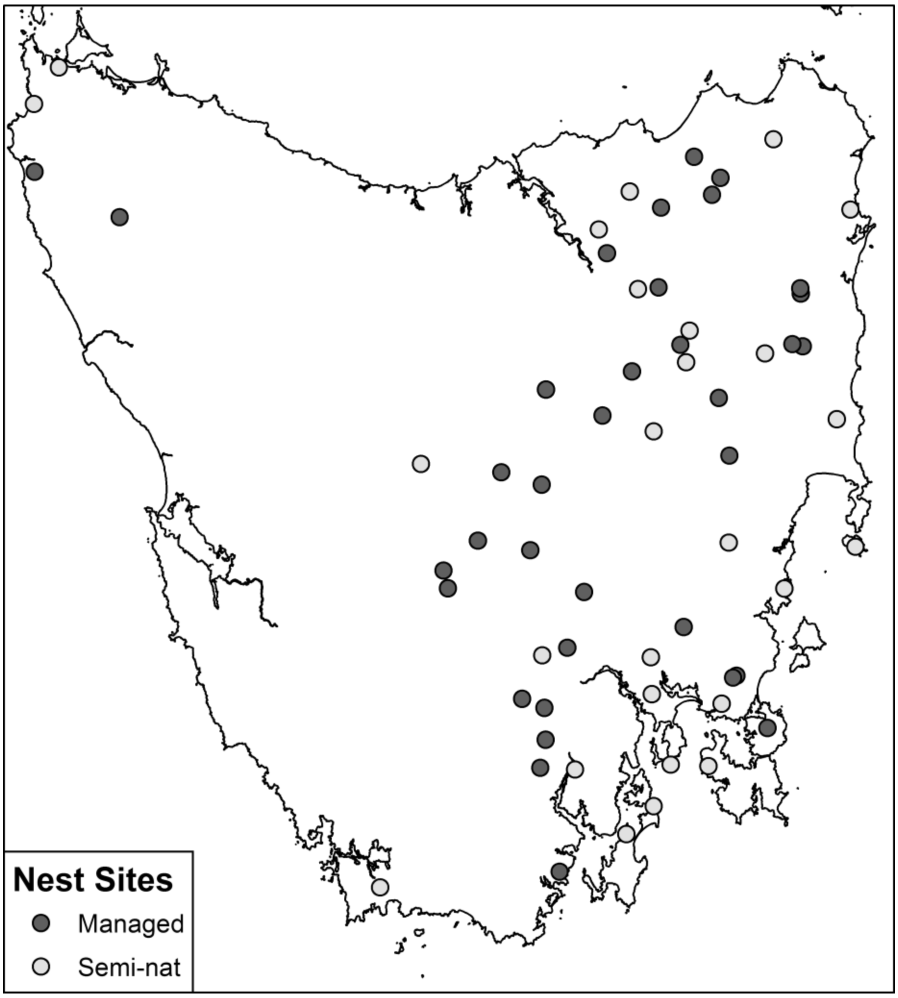


Figure 1 Location of the 61 managed and semi-natural nest sites monitored during 2008–09

Nest Use Assessment

Aerial surveys were conducted during November. Two nests that could not be found by air were surveyed from the ground by eagle specialists or forest planners during January 09.

Each nest was allocated an 'activity status' - 'not used', 'maintained' or 'successful' (Table 1). These categories were based on nest site characteristics and/or the presence of a nestling. Steenhof and Newton (2007) note that in order to compare nest success a standard minimum nestling age at which a nest is considered to be successful needs to be established. They recommend that this age should be '*when young are well grown but not old enough to fly and at a stage when nests can be entered safely and after which mortality is minimal until actual fledging*'. Although for many species this is when the age of the young is 80% of the age at which young leave the nest, nest success for some species may be based on the presence of younger nestlings where age at fledging varies or for other reasons (Steenhof and Newton 2007). In this current study nests were considered successful if they contained a large downy white nestling at least 4 – 6 weeks old (i.e. 33 – 50% of the age at which young leave the nest) (Table 1). Although this is slightly younger than the minimum age proposed by Steenhof and Newton (2007), older nestlings (>6 weeks) of the Tasmanian wedge-tailed eagle are extremely difficult to observe as their mottled brown plumage camouflages their presence (Wiersma, pers. obs.). In addition fledging age varies considerably in this species and mortality of nestling after the late downy/early feathering state is considered minimal compared with earlier stages in the nestling period (Mooney and Holdsworth 1991).

Table 1 Nest activity status categories

Activity status	**Observation**
Not used [1]	No signs of use, nest slumped and may be partially or fully bleached.
Maintained [1]	Sign of use[2] (e.g., significant signs of a compact nest platform, significant amounts of white-wash, green leaves, recently added brown sticks) but no egg or nestling observed.
Successful	Nests were considered "successful" if they contained a nestling 4-6 weeks or older. Such nests usually show significant amounts of down present around the immediate nest

[1] Nests classified as 'not used' or 'maintained' are collectively referred to as being 'unsuccessful'.

[2] Nest site use may be determined by investigating whether fresh white-wash, recently added green leaves and brown sticks had been added to the nest rim. During the early phases of breeding, green leaves continue to be added to a nest throughout the breeding attempt. White-wash (faecal matter) accumulates over time immediately below the nest or underneath limbs used as butcher sites or roosting platforms. Prey remains can also accumulate under a nest and so are a sign of nest use that becomes more obvious as the season progresses. Note: the quantity of whitewash is important to consider since vacant nests may contain white-wash, as adults frequent secondary or tertiary nests in their territory, although they may not be used for breeding.

Timing of breeding activity

Five phases of breeding were recognised in this study - courtship, incubation, hatching (which includes the nestling development stage), fledging and post-fledging nest dependence (Table 2). Courtship, nestling development and post fledgling nest dependence periods were based on estimated developmental periods described in the literature (DPIW 2008; Gaffney and Mooney 1992; Mooney 1997; Mooney 2000; Mooney and Holdsworth 1991).

Table 2 Phases of breeding

Breeding phase	Description
Courtship	Adults furbishing nests and preparing to lay (DPIW 2008). The minimum estimated period of courtship is 6 weeks (Wiersma pers. obs.).
Incubation	The time between the start of incubation and the hatching of an egg, during which the egg is kept at or near body temperature by the parent (Steenhof and Newton 2007). Estimated period is 6.4 weeks (43-45 days) (Gaffney and Mooney 1992)
Hatching	Includes the development stage of the nestling to its fledging state (12 weeks) (Olsen 1995).
Fledging	A fully- feathered young voluntarily leaving the nest for the first time (Olsen 2005; Steenhof and Newton 2007)
Post-fledging nest dependence	An average minimum estimate of time the young spends at the nest after fledging (6 weeks) (Brown, Mooney and Wiersma pers. obs.). Nest dependence varies considerably depending on the offspring's hunting skills, quality of territory and available prey (Olsen 1995).

Graphs of the timing of each breeding phase in the 08/09 season were produced by estimating the age of nestlings observed at nine nests surveyed from the air (during November), and working back to the start of the incubation period using the chronology of activities defined above. The observation of a nestling at one other nest, that was not surveyed as part of this study, was also used (V. Thompson unpublished data).

In order to compare with the 07/08 season a similar graph was produced using the estimated age of nestlings at 34 nests surveyed during November in 07/08. 22 of these nestlings were observed as part of the 07/08 survey (Wiersma et al, 09) the remaining 12 observations were were from data provided by the forest industry where the known age of young could be indentified from photographs.

Data analysis

A chi-square analysis was conducted to determine whether there is a significant difference between the expected frequencies and the observed frequencies in one or more categories (Fowler and Cohen 1992), was conducted to assess the significance of differences of nest success for managed and semi-natural nest categories (The level of statistical significance used, $P = 0.05$).

The usage of the 61 nests surveyed in 08/09 were compared with the results for the same nests reported in Wiersma *et al.* (2009) (07/08 season). Similarly the estimates of the timing of each breeding phase in 08/09 were compared with estimates made for the 07/08 season.

Results

Nest use

Only 15% of the 61 nests examined in 08/09 were successful (Table 3, Figure 2). Although the proportion of nests that were successful at 'semi-natural' sites (19%) was slightly higher than at 'managed' sites (11%) the difference was not significant (P=0.4). There was also no significant difference between the proportion of nests that were maintained at managed sites compared with semi-natural sites (20% and 27% respectively). A large proportion of nests in both categories showed no signs of use. The proportion of 'managed' nests that were not used (68%) was higher than the proportion of 'semi-natural' nests that were not used (54%). This difference, however, was not significant (P= 0.05). The location of successful nests (managed and semi-natural) are provided in Figure 3.

Table 3 Summary of activity status for the 61 nests examined in relation to land management context (managed and semi-natural sites) in 2008-09

Nest Category	Not Used	Maintained	Successful	Total No.
Managed	24	7	4	35
Semi-Natural	14	7	5	26
Total	38	14	9	61

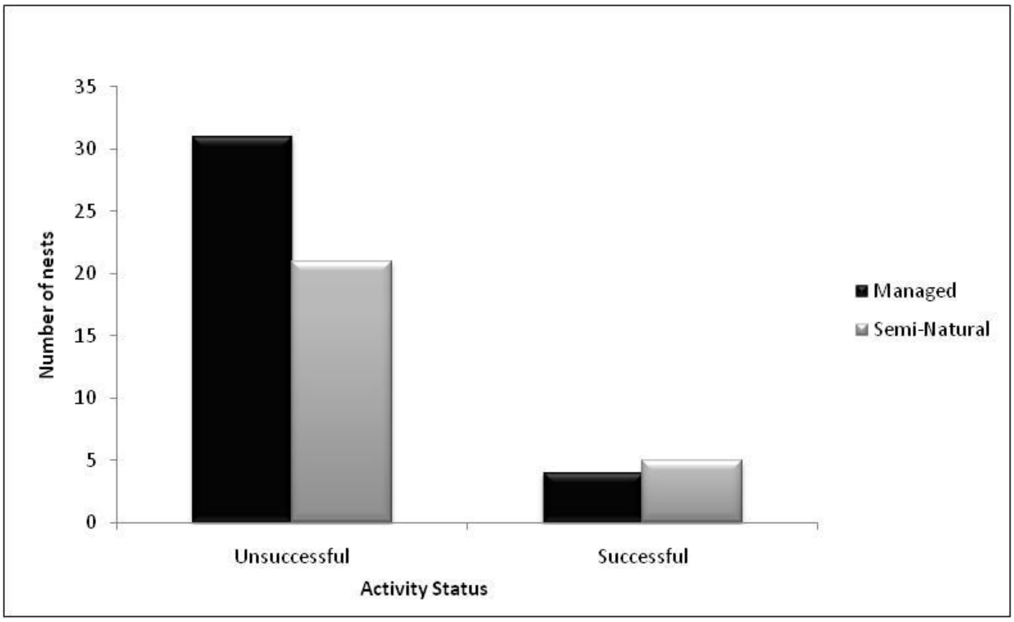
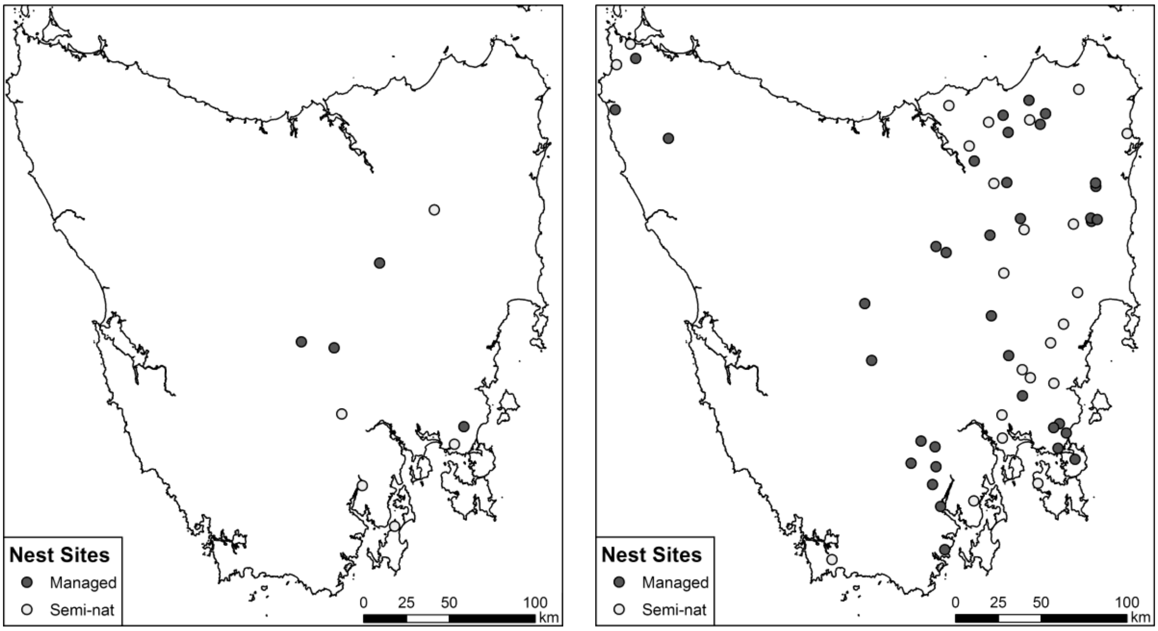


Figure 2 Number of nests in each land use category (managed and semi-natural) that were successful and those that were unsuccessful (maintained and not used categories).



(a) **(b)**

Figure 3 Location of (a) successful nests and (b) unsuccessful (not used or maintained) nests during 2008 –09 aerial surveys.

The proportion of nests that were successful in 08/09 was a lower than the proportion recorded during 07/08 (Table 4, Figure 4). Five of these were successful in both 07/08 and 08/09. Six were not found to be successful in 08/09, although they were recorded as 'maintained'. Seven showed no signs of use during the 08/09 season.

Eleven of the 61 nests surveyed in 08/09 were recorded as 'maintained in 07/08. Two of these were successful in 08/09 (Table 4), five were maintained in 08/09 and four showed no signs of use in 08/09 (Appendix D). Two of the 61 nests were successful in 08/09 but had not been successful or maintained in 07/08. Both the 07/08 and 08/09 results suggest that a large proportion of the nests surveyed in this study are not used in any given year, and that not all nests considered 'active' produce nestlings. The results indicate that sites that were successful in a previous year are more likely to be successful or maintained in following years, compared to sites that are just maintained in previous years.

Table 4 Summary of the use of 61 nests over a two year period from 2007/2008 (Yr 1) & 2008/2009 (Yr 2).

	No. Nests Successful 07/08 season	No. Nests Successful 08/09 season	Nests not used over 2 years	No. of same nests Maintained over 2 years	No. of same nests successful over 2 years	Successful Yr 1 Maintained Yr 2	Maintained Yr 1 Successful Yr 2	No of nests occupied in some way over two years (i.e. Maintained &/or Successful categories)
Managed	7	4	19	3	3	2	1	7
Semi-natural	11	5	8	2	2	4	1	9
Total	18	9	27	5	5	6	2	16

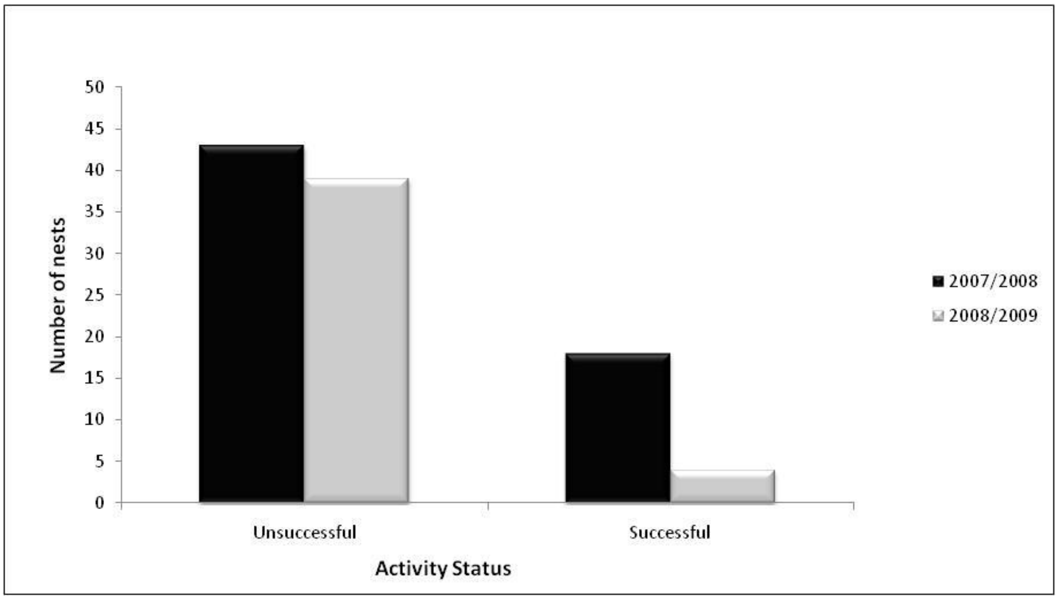


Figure 4 Number nests (n=61) surveyed in both 07/08 and 08/09 that were successful or unsuccessful.

Timing of breeding phases

During the 08/09 season the commencement of incubation varied up to eight weeks between pairs (Figure 5). The peak incubation period, defined as the period when most birds were laying (Table 2), occurred during the fourth week of October (Figure 5).

The period showing hatching, which includes the chick developmental period, occurred over a four month period with the peak during mid December. The breeding season, which includes the courtship and post fledging nest dependence, occurred over a period of just over nine months with birds being at nests for up to six months and three weeks (Figure 5).

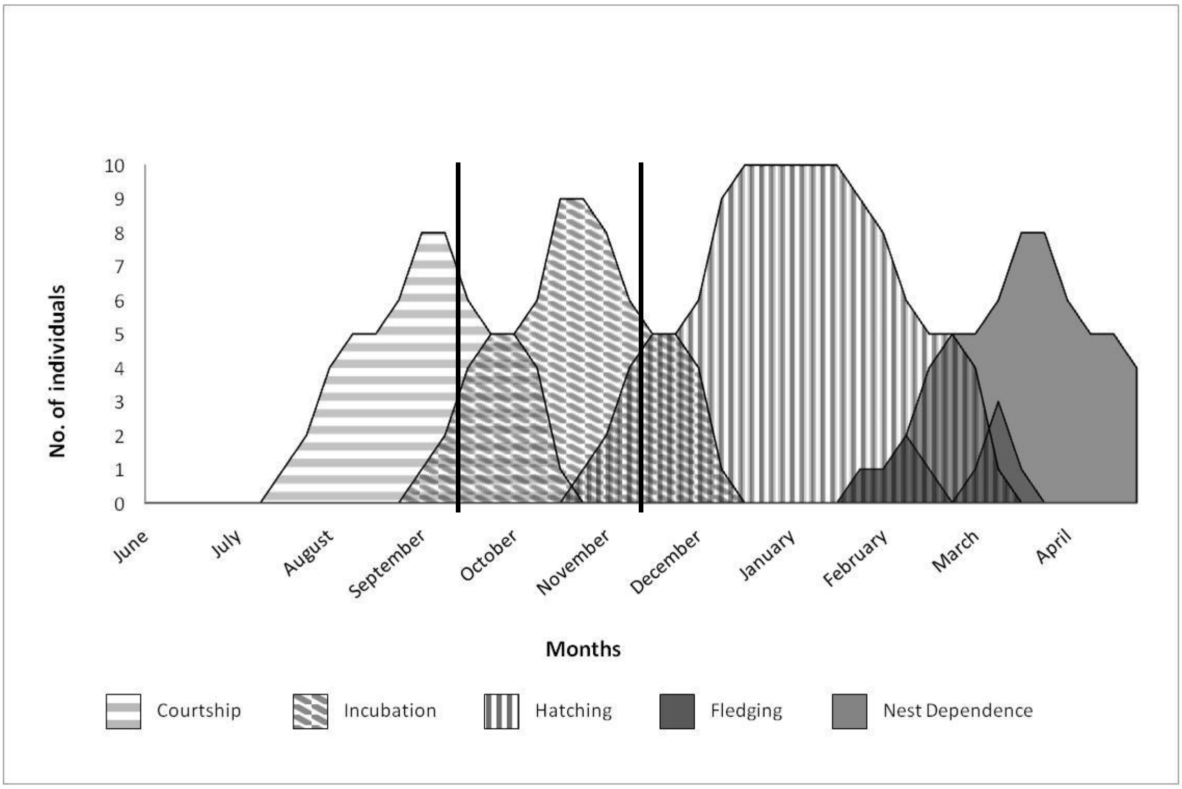


Figure 5 Chronology of the 08/09 breeding season based on estimated hatch dates of 10 breeding pairs, with black lines defining the time at which forest planners check the activity status of some nests. The graph shows a generalised estimate of breeding stages based on all available data.

A comparison of the estimated timing of breeding events between years (07/08 – 08/09) shows that the commencement of incubation during the 08/09 season was approximately five weeks later than in 07/08 (Figure 5 & 6 respectively). The marked difference in the commencement of incubation resulted in a late fledging period which saw the last nestlings fledge during the 4th week of March 09, four weeks later than the 07/08 breeding season (Figure 6).

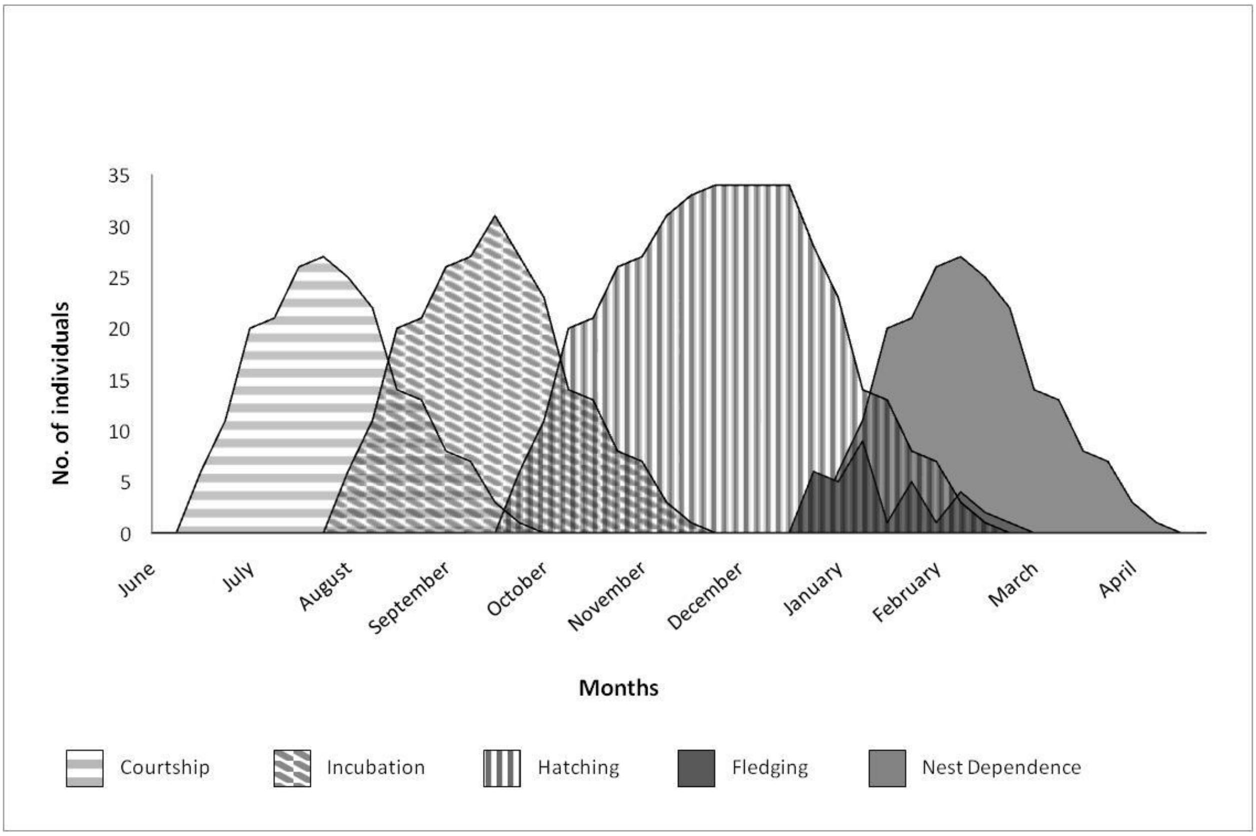


Figure 6. Chronology of the 07/08 breeding season based on estimated hatch dates of 34 breeding pairs, with black lines defining the time at which forest planners check the activity status of some nests. The graph shows a generalised estimate of breeding stages based on all available data. .

Discussion

The results of this study have added to our understanding of nest use and timing of breeding in the Tasmanian wedge-tailed eagle. Only a small proportion of nests surveyed in both 07/08 and 08/09 were used and the timing of breeding varied between the two years.

It is possible that in some areas eagles frequently change nests within territories which could account for the apparent lack of breeding at some of the nests surveyed in this study. However, it is difficult to confirm this without knowing the boundary of the territory for each pair and the location of every nest within that territory. The location and number of wedge-tailed eagle territories are difficult to estimate as territory boundaries are dynamic. Olsen (2005) notes that wedge-tailed eagles may use the same nests repeatedly but, in one study, 48 per cent of nesting attempts were in refurbished nests and only 20 per cent were occupied twice in a 10-year period and then rarely in successive years. If nests were undisturbed they were more likely to be used in successive years (Olsen 2005).

While eagle territories are reported to remain relatively stable (Mooney 2005; Olsen 2005) other research indicates that breeding territories may be relatively dynamic accounting for a 25 per cent variability where environments are less predictable (Olsen 2005). This suggests that drought periods have the potential to influence the predictability of nesting environments. Where nesting territories occur within stable nesting environments variability may account for as little as 10 per cent annually (Olsen 2005).

The low proportion of nests used in both 07/08 – 08/09 may also be because of low natural fecundity in the wedge-tailed eagle. There are large energetic costs involved in producing offspring (Olsen 2005). Anecdotal observations suggest that young wedge-tailed eagles may at least occasionally stay with adults for several seasons after fledging (Wiersma and Brown pers obs). White-bellied sea eagle *Haliaeetus leucogaster* offspring also appear to stay dependent on their parents up until the following breeding season and fledgling sea eagle offspring have been observed sitting on limbs adjacent to nests while adult female sea eagles incubate (Wiersma pers obs). However, without banding it is difficult to confirm that the adults are the parents.

Results from this study have shown that although the duration of breeding phases may be similar between years, the timing of breeding may vary considerably between years. Breeding was estimated to occur approximately five weeks later in 08/09 than the previous year. Peak incubation occurred during the first week of September in 07/08 (Wiersma et al, 2009), however in 08/09 peak incubation occurred during the second week of October (Figures 5 & 6). While only a small number of nestlings at 10 nests were used to estimate chronology of breeding events in 08/09 observations made on other nests with nestlings across the state confirmed the timing (figure 5) (B. Brown and V. Thompson pers. obs). The marked difference in the commencement of incubation resulted in an understandably late fledging period which saw the last nestlings fledge during the 4th week of April 09. However, while the breeding period showed a definite shift in the timing of breeding events (i.e. incubation, nestling development, fledging etc.) between the 07-08 and 08-09 seasons the overall duration of the breeding season was the same (i.e. 10 months). This suggests that while pairs may breed at different times from each other, neighbouring pairs may be affected by small climatic differences or food availability at a regional scale. Among sea eagles, one pair may concentrate on hunting shearwaters and the other on fish with different peaks in food availability and triggers to breeding (Mooney pers. com.). A consequence of breeding failure early in the season may also spark a second laying period, much later in the season (Olsen 2005). Without constant monitoring of nests, pairs that fail early in the season may be mistakenly considered as late breeders.

The difference in the number of nestlings produced and the timing of breeding observed between the two years may be explained by the significant drought experienced in 08/09 across Tasmania. Data provided by the meteorological bureau shows that 08/09 was one of the top 20 warmest years in Tasmania since 1910 (when comparable records began) and had drier than average rainfall in most areas (Barnes-Keoghan 2010). Lack of rainfall is known to have a profound impact on plant productivity and subsequently on macropod populations (Grigg *et al.* 1985; Olsen and Braysher 2000). The short-term population reduction in macropod species and other prey species may have had a significant short-term impact on breeding by eagles in 08/09.

A trend toward a shift in the breeding season has been observed in other bird species (Filippi-Codaccioni *et al.* July 2010) It has been suggested that such shifts in breeding patterns are the result of climate change, with warmer temperatures pushing certain species to breed at different times, to synchronize with the shift in prey species movements or breeding patterns. Among Aquila eagles, fluctuations in herbivore populations are likely to be the biggest influence on breeding (Olsen 1995). Also changes in pollination times, through seasonal or climatic variations will influence the period when grasses develop (Knapp 1984), the primary food source of herbivores . A more detailed study comparing flowering (e.g. *Acacia dealbata*) times with the onset of incubation in eagles might provide some useful information.

Another explanation for the differences in the number of nestlings produced between the years might be that the Tasmanian wedge-tailed eagle is sometimes a biennial or triennial breeder, with more breeding events in particular years. The different breeding patterns observed during the past two years of this study provide support for continued monitoring into the future to evaluate and understand the natural breeding trends of this species. The variation in the proportion of sites that produced nestlings between years has not been taken into account previously when estimating state-wide population trends for this species (Forest Practices Authority 2007; Mooney and Holdsworth 1991). The possibility of biennial or triennial breeding behaviour may have certain management implications for the forest industry. The potential for forestry activities in the vicinity of nests during years when pairs do not breed to impact on breeding at these nests in subsequent years needs consideration. While eagles may not use a nest for breeding activities during a particular year, eagles are known to frequently visit all nests in a territory throughout the year (Olsen 2005). Activities that cause disturbance to nests during breeding years may be just as likely viewed as a disturbance during non-breeding years.

Annual reproductive rate is commonly estimated as nestlings/territory (Gaffney and Mooney 1992). However, as mentioned above, the location and number of wedge-tailed eagle territories are difficult to estimate as territory boundaries are dynamic. There are three sources of estimated annual reproductive rates presented as nestlings/nest for the Tasmanian wedge-tailed eagle (Mooney 2005; Mooney and Holdsworth 1991; Threatened Species

Section 2006). Such estimates vary widely and are based on little consecutive sampling of individual nests (Appendix B).

The results from the past two years of surveys carried out in this study may be used to estimate state-wide reproductive trends (Table 5). The estimate of 191 chicks produced from the total number of nests known across the State (1076, Department of Primary Industries and Water, Raptor Nest Database 1/1/2010), was obtained by extrapolating from the data collected during the 07/08 survey (84 nests) and 08/09 survey (61 nests). It could therefore be an underestimate of the actual total number of nestling produced across the State. However, 191 chicks produced across the State per year is similar to the estimate made by Mooney (2005) (Table 6). Mooney's estimate is based on the proportion of nests and territories that are successful in past years in different disturbance categories (Mooney and Taylor 1996).

Table 5 Estimated state-wide reproductive trends based on data from 83 nests surveyed in 07/08 and 61 nests surveyed in 08/09.

	Proportion of nests that produce a nestlings	**Average State-wide number of nestlings/year**	**Average no. nests not used annually**	**Average no. nests used* annually**
Total	14.9%	191	440	636

Note: Trends are based on data from 83 and 61 nests over two years with estimates based on the total no. of eagle nests known (n= 1268), recorded by DPIPWE Raptor Nest Database 1/1/2010. Estimates are based on the assumption that random selection of nests sites approximates trends occurring across the range of nests recorded in the raptor nest database. *Maintained and successful

Table 6 Estimated wedge-tailed eagle annual productivity estimated by Mooney in the Federal Court of Australia, Robert Brown and Forestry Tasmania Commonwealth of Australia State of Tasmania, No. TAS 17 of 2005

	Average annual productivity (nestlings)	Estimated no. active territories	Estimated no. Territories
Total	214	255	457

Note: Data is derived from approximately 833 known nests at the time of publication

Management Implications

The shift in the start of breeding during 08/09 had some significant implications for forest management. Aerial surveys showed that the majority of nests contained very young nestlings compared to the same time the previous year. This information was used to modify management practices (restriction of forestry activities) during August 08/09, a period when very few pairs were incubating. The period during which management activities were restricted was also extended to the end of March to give nestlings time to fledge from nests without being disturbed. This extension resulted in lost productivity for the forest industry and reduced time for browsing and burning activities due to equipment and demand on personnel between non-breeding months.

The time at which the first 'activity check' was conducted (second week of September) as part of routine planning procedures (Forest Practices Board 2000) potentially provided a number of false negatives. Of the 280 nest activity checks conducted by the industry during September (during 08/09) only 44 of these were resurveyed during November while 68 nests were considered inactive. If we consider the trends presented in this present study it would suggest that a number of the latter nest sites might have appeared to be inactive at this time but could in fact have been active as these pairs would not have commenced incubation (Figure 5). Two of these sites were later found to have had a nestling after all, although it is not known if they survived to fledging. Incorrectly assessing nest sites as inactive have obvious serious ramifications for the success of breeding pairs. Incorrect assessments of the status of nests, and the need for management actions, could amount to a large number of nests being abandoned.

Results from the nest characteristics survey conducted during the 07/08 season using classification tree analysis implies that not all nests can be clearly identified as active/inactive from nest characteristics alone and that only a few nest characteristic are reliable at certain times of the year (Wiersma and Koch *in review*). It is common for incubating adults to sit low in a nest when nests are approached by observers. In particular nests that are large, have bleached side walls, or are viewed from below present special circumstances where observations are difficult to obtain correctly. Given the difficulty in being able to determine when the breeding season commences and the chance of incorrectly assessing activity status of a nest using indirect signs (during September) consideration should be given to just having one single nest check during the November period. Assessments at this time provide greater certainty of occupancy whilst also providing additional productivity data which can be used to better manage eagle habitat. The implementation of single nest checks during November would also reduce the disturbance associated with checking nests during the most sensitive period of breeding (incubation).

Conducting single nests checks (during November) would provide a variety of benefits for eagles and the forest industry, they include:

1) Favours reproductive output for eagles as critical areas (500m and 1km line of sight from nests) would have no activity near them during sensitive periods if a nest check resulted in a false negative. This would likely favour pairs that breed irregularly, i.e. every second or third year, pairs that are regularly disrupted by activity in non-breeding years.

2) Indirect signs of nest 'status' are more easily observed during November and hence using nest site characteristics to assess nest' status' is more reliable.

3) Provides information on reproductive output. During November young nestlings can be observed at the majority of nest sites unless nests are difficult to see into. These nests should be considered active during the breeding season unless proven otherwise during a fixed wing aircraft survey.

4) Single visits to nests during a season halve the disturbance created by ground visits.

5) Reduces the cost of eagle management to the industry by halving the number of ground checks.

It is acknowledged, however, that only one activity check during November has implications for wood production activities because during some years large areas may be excluded. The development of a way to determine the timing of breeding activities early in the season may assist with decisions on the timing of activity checks.

Conclusion

Comparison of 07/08 and 08/09 data suggests that eagles may breed irregularly or may frequently move about within territories occupying various nests. Without a more detailed approach to nest monitoring it is difficult to draw conclusions.

This study also suggests that although the duration of breeding phases may be similar between years, the timing of breeding in the Tasmanian wedge-tailed eagle may vary considerably between years. If these trends continue they have implications for future eagle habitat management, particularly during non-breeding years when eagles may still frequent nests but not be easily observed during activity checks. Future nest site monitoring should allow a more comprehensive investigation of the breeding trends.

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Appendices

Appendix A: Project Milestones, Key Activities, and Dates for Priority Action Achievements

Activity	Milestone (Underlined where also an output).	Achievement Indicator	Progress
Selection of additional 'control' and 'managed' nest sites in areas in each bioregion of the State.	Addition of new 'managed and 'semi-natural nest sites to the project nest site database.	Sites selected and locality confirmed by August 09.	Completed
Continue collection of tree and site level variables (including disturbance and protection measures) for each nest site using methods established in 07/08.	Completion of environmental variable data collection.	Environmental variable data collected and entered by May 09.	Ongoing
Data analysis.	Completion of data analysis. The relationship between nest site characteristics (including degree of disturbance and protection measures) and nest use and productivity will be explored using Generalised Linear Modelling (McCullagh and Nelder, 1989) in which link functions appropriate to the outcomes will be used, such as	Data analysed and summary graphs/tables	Ongoing

Activity	**Milestone** (Underlined where also an output).	Achievement Indicator	Progress
	a logit link for fledging success. The model will be conducted using Bayesian methods to properly account for uncertainty in variables and potentially in the model. It is expected that the model results will also form a component of a larger Bayesian population viability model.		
Complete the monitoring of the implementation of eagle nest management prescriptions for 2007/08 FPPs.	Analyse the data collected and summarise for report.	Relevant report chapter completed in March 2010.	To be assessed
Write-up of 08/09 report on first two years of project.		Delayed due to difficulties in getting the required spatial data.	Completed in October 2010
Collate results/information and produce a final report including detailed results of the three year project work and recommendations for future monitoring. Report will include any recommendations for changes to the conservation management actions for the maintenance of nesting habitat	Complete 3 year Final Report	Final report and recommendations used to inform the revision of management actions.	In Progress

Activity	**Milestone** (Underlined where also an output).	**Achievement Indicator**	**Progress**
for the wedge-tailed eagle.			
Planning for 2010/11 annual nest survey	2010/11 survey data	Data provided by aerial survey	To be Completed
Determine the timing of breeding events in 08/09	Define breeding stages and time spent by eagles at each stage to provide timeline of events from known age nestlings	Development of Graphs from known age nestlings	Completed
Explore the relationship between nest success and forest patch size	Estimate patch size and conduct analyses	Results from statistical analyses	Completed
Review Wedge-tailed eagle habitat model from data collected from field work	Collect Tree level data	Production of new WTE habitat model	Ongoing

Appendix B - Summary of nest success rates for the Tasmanian wedge-tailed eagle from various authors

Source of data	Year of study	Description of nest location	Number of nests assessed	Nest success rate %	Nestlings/nest
Mooney and Holdsworth (1991)	1989	Disturbed[1]	19	43	0.43
		Little disturbed[2]	11	84	0.84
Mooney and Taylor (1996)	1996	-	11	60	0.60
State of the Forests Report (Forest Practices Authority 2007)	2000	-	206	27.7	0.27
	2001	-	127	22.04	0.22
	2002	-	72	20.8	0.20
	2003	-	67	4.47	0.04
	2004	-	92	19.5	0.19
	2005	-	209	10.05	0.10
Mooney and Brown, unpublished data reported in Brown vs Forestry Tasmania, Federal Court of Australia,	2000	Disturbed	129	23.3	0.23
		Little Disturbed	43	39.5	0.39
	2001	Disturbed	93	14	0.14
		Little	27	51.9	0.51

2005		Disturbed			
This study	07/08	Disturbed [3]	49	20.4	0.20
		Little Disturbed [4]	35	34.3	0.34
	08/09	Disturbed	35	11	0.11
		Little Disturbed [4]	25	20	0.20

[1] clearfell/clearing, partial harvest, roading/quarrying, intensive farming, intensive recreation, directed disturbance, [2] non-intensive farming and non-intensive recreation, [3] called managed sites in this study, [4] called semi-natural sites in this study.

Appendix C Wedge-tailed eagle nests surveyed during the 07/08 and 08/09 breeding seasons

NEST_ID	Category	Nest surveyed 07_08	Nest Surveyed 08_09
91	Semi-nat	Yes	Yes
121	Managed	Yes	Yes
122	Managed	Yes	No
127	Semi-nat	Yes	Yes
128	Managed	Yes	Yes
203	Semi-nat	Yes	Yes
205	Semi-nat	Yes	Yes
233	Semi-nat	Yes	Yes
245	Semi-nat	Yes	Yes
294	Semi-nat	Yes	No
308	Semi-nat	Yes	No
328	Semi-nat	Yes	Yes
390	Semi-nat	Yes	No
426	Semi-nat	Yes	Yes
433	Semi-nat	Yes	Yes
470	Managed	Yes	No
471	Semi-nat	Yes	Yes
495	Semi-nat	Yes	Yes
498	Semi-nat	Yes	Yes
504	Managed	Yes	Yes
570	Managed	Yes	Yes
591	Semi-nat	Yes	Yes
595	Managed	Yes	Yes

612	Managed	Yes	No
614	Managed	Yes	No
696	Semi-nat	Yes	No
697	Managed	Yes	No
753	Semi-nat	Yes	No
756	Managed	Yes	Yes
797	Managed	Yes	Yes
804	Managed	Yes	Yes
820	Semi-nat	Yes	Yes
877	Managed	Yes	Yes
908	Semi-nat	Yes	Yes
911	Managed	Yes	No
917	Semi-nat	Yes	Yes
938	Managed	Yes	Yes
944	Semi-nat	Yes	No
945	Semi-nat	Yes	Yes
977	Managed	Yes	Yes
987	Semi-nat	Yes	Yes
996	Managed	Yes	Yes
1018	Semi-nat	Yes	Yes
1032	Managed	Yes	Yes
1049	Managed	Yes	No
1071	Managed	Yes	No
1080	Managed	Yes	Yes
1083	Managed	Yes	No
1093	Managed	Yes	No
1198	Semi-nat	Yes	Yes
1201	Semi-nat	Yes	No

1208	Managed	Yes	Yes
1211	Semi-nat	Yes	Yes
1230	Managed	Yes	Yes
1233	Managed	Yes	No
1234	Managed	Yes	Yes
1235	Managed	Yes	Yes
1258	Semi-nat	Yes	Yes
1262	Managed	Yes	Yes
1299	Managed	Yes	Yes
1307	Managed	Yes	Yes
1320	Managed	Yes	Yes
1321	Semi-nat	Yes	Yes
1366	Managed	Yes	Yes
1379	Managed	Yes	No
1381	managed	Yes	Yes
1382	Semi-nat	Yes	Yes
1384	Managed	Yes	Yes
1422	Semi-nat	Yes	No
1432	Managed	Yes	Yes
1446	Managed	Yes	Yes
1454	Managed	Yes	Yes
1471	Managed	Yes	Yes
1472	Managed	Yes	Yes
1481	Managed	Yes	Yes
1506	Managed	Yes	Yes
1523	Managed	Yes	Yes
1531	Semi-nat	Yes	Yes
1576	Managed	Yes	Yes

1580	Semi-nat	Yes	Yes
1581	Managed	Yes	Yes
1585	Managed	Yes	Yes
1611	Semi-nat	Yes	Yes

Appendix D: Activity status of wedge-tailed eagle nests over two consecutive years, 07/08 – 08/09

Results from the same 61 nests between 07/08 – 08/09

Category	**07_08**	Managed	Semi	**08_09**	Managed	Semi
Not Used	**32**	21	11	**38**	24	14
Maintained	**11**	7	4	**14**	7	7
Successful	**18**	7	11	**9**	4	5